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A PROGRESS REPORT - STUDY OF COARSE SLURRY, SHORT-DISTANCE PIPELINING

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A PROGRESS REPORT - STUDY OF COARSE SLURRY, SHORT-DISTANCE PIPELINING

by

L.B. Geller*

ABSTRACT

An agreement was signed in 1971 by the governments of Canada and the Federal Republic of Germany on scientific and technical cooperation. Coal slurry systems were identified as one of the several areas of mutual interest. Four particular system areas were also identified at a joint consultative meeting in early 1984, and a Memorandum of Understanding signed accordingly. One of the four areas deals with the field of coarse-slurry, short-distance pipelining. This report reviews progress achieved in the latter program.

After establishing full details of a proposed joint Canadian/German project, work commenced on the Canadian part of this program. To date, a series of experiments has been completed, covering tests in a 250 mm pipeline with both sand and coal-slurries, plus an array of physical slurry-parameter measurements. These data have been used for calculations, to further develop a fundamental model of slurry-flows in horizontal pipelines. As a result the correctness of the mechanistic, two-layer modelling approach was vindicated, while parametric details in some functions were rewritten.

Moreover, the immediate practical relevance of these results was also illustrated, by noting their applicability to the solution of control - problems that have arisen in Canadian tar-sands pipelining practice, due to a change in particle sizes. Wider implications, as to the general industrial relevance of slurry-pipelining research, were similarly noted.

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Finally, this report examines the reasons for recommending completion of the entire originally scheduled Canadian test program. It also examines details of a simplified program for the German group, which takes account of the limitations which, to date, prevented this group from participating in the joint effort.

RAPPORT SUR L'ÉTAT D'AVANCEMENT DES TRAVAUX SUR L'ÉTUDE DU TRANSPORT DES COULIS GROSSIERS PAR PIPELINES SUR UNE COURTE DISTANCE

par

L.B. Geller*

RÉSUMÉ

En 1971, un accord de coopération scientifique et technique a été signé entre le gouvernement du Canada et la République fédérale d'Allemagne. On a déterminé alors que les systèmes de coulis de charbon étaient l'un des nombreux domaines d'intérêt commun. Lors d'une réunion consultative conjointe en 1984, on a choisi quatres systèmes en particulier; une Entente a été signé par la suite. Un des quatres domaines choisis traite du transport des bouillies grossières par pipelines sur une courte distance. Le présent rapport révise les progrès accomplis dans ce dernier programme.

Après avoir établi les détails du projet conjoint proposé entre le Canada et l'Allemagne de l'Ouest, les travaux ont débuté au Canada sur la partie canadienne du programme. À cette date, une série d'essais a été complétée comprenant des essais effectués à l'aide d'un pipeline de 250 mm avec des bouillies de sables bitumineux et de charbon ainsi qu'une gamme de mesures physiques des paramètres des bouillies. Les données obtenues de ces essais ont été utilisées pour effectuer des calculs et mettre au point un modèle de base de l'écoulement des bouillies dans les pipelines horizontaux. L'exactitude de l'approche mécaniste de la modélisation à deux niveaux a donc été démontré alors que les détails paramétriques de certaines fonctions ont été réécrits.

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On présente de plus dans ce rapport, l'apport pratique immédiat et pertinent de ces résultats en soulignant leur applicabilité à la résolution des problèmes de contrôle causés par les méthodes canadiennes de transport des sables bitumineux par pipelines, dans lesquelles un changement de la dimension granulométrique a eu lieu. On a aussi constaté qu'il y avait au niveau industriel de plus grandes implications quant à la pertinence des travaux de recherche sur le transport des bouillies par pipelines.

Enfin, ce rapport étudie aussi les raisons de recommander l'achèvement du programme de recherche canadien tel que planifié au début. Il contient de plus, les détails d un programme simplifié pour le groupe allemand; ce programme tient compte des limitations qui jusqu'à présent ont empêché ce groupe de participer à l'effort conjoint.

CONTENTS

	Page
ABSTRACT	i
RÉSUMÉ	iii
BACKGROUND	1
INTRODUCTION	2
List of Consultative Group Members	2
Introductory Remarks by Canadian Group Members	2
Introductory Remarks by the German Group Member	3
DISCUSSION OF NEWLY ACQUIRED CANADIAN TEST DATA, AND OF THEIR IMPLICATIONS	4
Technical Results	4
Practical Implications of Latest Canadian Test Results	5
General Industrial Relevance of Slurry-Pipelining Research	5
DISCUSSION OF RECOMMENDED FUTURE GERMAN WORK	9
DISCUSSION OF RECOMMENDED FUTURE CANADIAN WORK	11
TIMING OF NEXT CSWG MEETING	12
SUMMARY	12
REFERENCES	14
APPENDIX A - CANADA/FRG MOU ON COAL SLURRY SYSTEMS	16

BACKGROUND

An agreement was signed in 1971 by Ministers Jean-Luc Pepin and Walter Scheel, for the governments of Canada and the Federal Republic of Germany, respectively, on scientific and technical cooperation (see Appendix 'A' of Ref. 1). Its purpose was:

(a) to broaden the scope of all aspects of scientific and technological cooperation between the two countries, for peaceful purposes and for their mutual benefit; and
(b) to facilitate and to encourage scientific and technological cooperation and exchanges of information.

One special field for cooperation agreed to under the terms of this document is that of coal-slurry systems. Details of the proposed cooperation are covered by a Memorandum of Understanding (MOU), signed in 1984 by Dr. W.G. Jeffery for CANMET in Ottawa, and by Dr. Finke for the B.M.F.T. in Bonn (Appendix 'A'). The four specific areas referred to in this MOU are:

(1) Dense-coal slurry systems, including their preparation, transportation, combustion and marketing/commercial aspects;
(2) Hydraulic transportation of coking coals;
(3) Coarse-coal slurry, short-distance pipelining; and
(4) Preparation of a manual on the design of slurry pipelines.

The contact persons identified by the MOU for research area (3) are L.B. Geller of CANMET's Mining Research Laboratories in Ottawa, and Professor Dr. Ing. F.J. Geller of WBK's Mining Engineering Department in Bochum. They were charged with preparing a report, detailing the objective, methodology, costs and time-table of a mutually acceptable joint R&D project on coarse-slurry, short-distance pipelining. Such a program was duly developed and reported on (1). It was submitted to the Canadian and German coordinators designated by the MOU (Dr. T.D. Brown and F. Fiseni, respectively), and accepted by them. As a consequence, an appropriate laboratory pipelining research contract was devised and initiated by CANMET, as Canadian signatory of the agreement in question.

Unfortunately funding difficulties prevented the German group from undertaking thus far any of the joint, and mutually complementary, research work previously agreed to. In the meantime the Canadian research had, however, advanced to about the half-way mark of the originally scheduled program. Dr. T.D. Brown suggested, therefore, that if interested, the German group might wish to send Professor F.J. Geller, as their representative to Canada to discuss and comment upon the preliminary Canadian research results. This invitation was accepted with alacrity. Accordingly, a consultative group meeting was arranged in Saskatoon for November 18 and 19, 1985, with preparatory discussions in Toronto on November 16 and 17 between the contact persons of the two groups. A post-session meeting between Professor F.J. Geller and Dr. T.D. Brown, at CANMET's Devon Laboratories, was also arranged for November 19 and 20.

The following sections of this report give details of the items discussed at the above mentioned series of meetings.

INTRODUCTION

LIST OF CONSULTATIVE GROUP MEMBERS

The following attended the consultative-group meeting, held at the pipelining laboratories of the Saskatchewan Research Council (SRC) in Saskatoon on November 18 and 19, 1985:

Professor Dr. Ing. F.J. Geller, of the WBK in Bochum;
Professor Dr. C.A. Shook, of C.A. Shook Consulting Ltd. (and of the University of Saskatchewan);
Dr. W.H.W. Husband, of the SRC;
R.G. Gillies, of the SRC;
M.H. Small, of the SRC;
M.W. Mikhail, of CANMET, Devon;
L.B. Geller, of CANMET, Ottawa.

INTRODUCTORY REMARKS BY CANADIAN GROUP MEMBERS

The meeting was chaired by L.B. Geller, who extended a warm welcome to Professor F.J. Geller on behalf of the entire Canadian group. While disappointed that, so far, their German counterparts had been unable to proceed with any of the research originally outlined in the joint report of July 1984

(1), the Canadian group well understood the severe limitations current economic difficulties imposed on basic research efforts in both Germany and Canada. It was sincerely hoped though, that at least some of this work might yet be undertaken in Germany, especially in view of the very promising nature of the newly acquired Canadian test data. Moreover, such a German decision might also positively influence future Canadian considerations as to further work on the originally agreed upon complementary program.

The latest Canadian test results will be published in two contract reports, one dealing with the broad fraction coarse-coal-slurry tests in a 250 mm pipeline, and the other with the series of narrow fraction gravel/sand slurry tests, also in a 250 mm pipeline loop. It is also planned to render an account of these test results at the Tenth Hydrotransport International Conference of the BHRA, in 1986.

For purposes of the present meeting a draft version of the contractor's report on the sand-slurry tests (2) was made available to all members of the consultative-group. It describes the series of tests performed with five narrow fraction gravel/sand slurries in a 250 mm pipeline, plus the concomitant set of physical parameter determinations, as originally called for under the headings of a 'Core Project' and a 'Work Statement', in CANMET Report 84-70(1). An in-depth discussion of these results led to the set of conclusions outlined in the next main section of this report.

INTRODUCTORY REMARKS BY THE GERMAN GROUP MEMBER

Professor F.J. Geller expressed his thanks for the cordial welcome. He observed that, unfortunately, for the time being there was next to no possibility of any new tests being conducted in Bergbauforschung's pipelining laboratories at Essen. This is because the German coal industry, who control this laboratory's work schedule and also have to share in its costs, are unconvinced about the practical applicability of slurry-pipelining to the solution of their problems. All the same, there was considerable interest in Germany in keeping abreast of latest developments in the field of fundamental hydrotransport research. This interest was shared by consulting, design, as well as research oriented organizations. In fact, Professor Geller himself constantly received enquiries, relevant to slurry transportation, from industrial and commercial organizations (e.g., from SIEMAG, WIRTH, MAV SCHAUENBURG, and others). Consequently, he was grateful for the opportunity to discuss the Canadian test results and to examine possibilities of future work in

Germany. He was also pleased to be able to table three recent, and yet unpublished documents of his own organization, dealing with the question of coarse-slurry pipelining (3,4,5).

DISCUSSION OF NEWLY ACQUIRED CANADIAN TEST DATA, AND OF THEIR IMPLICATIONS

TECHNICAL RESULTS

The major conclusions arrived at, as to the development of a reliable slurry pipelining model, are as follows:

(a) The fluid viscosity, rather than the slurry viscosity, appears to determine the contact-load fraction of the mixture - at least for mixtures containing less than 35% solids by volume.

(b) The in situ volumetric concentration, rather than the delivered concentration, has been shown to be the appropriate parameter for use in the model.

(c) For solids with a size distribution of moderate breadth, the mass mean particle diameter "d_{50}" is the appropriate parameter.

(d) The tests have provided results for a range of particle sizes (up to 6 mm) in a 250 mm pipeline.

(e) Existing sand-data provide information on the effect of the pipe diameter only for 0.18 mm particle sizes.

(f) The ratio of particle diameter 'd', to pipe diameter 'D', is of considerable importance in determining the contact load. This effect is much greater than previously indicated.

(g) A tentative correlation for the prediction of the contact-load ratio has been obtained, using the data in items (d) and (e). This correlation is most reliable in the region covered by the present experiments. However, further work is required, involving pipes of other sizes, in order to vary the experimental d/D ratios. The exponential form of the tentative correlation satisfies the known limiting conditions.

(h) In contrast to clay-water mixtures, clay-water-sand slurries exhibited complex rheology in some cases. The composition of the sand was found to be very important; it must, therefore, be carefully controlled during tests. The model's treatment of this effect will have to be considered at a later date.

PRACTICAL IMPLICATIONS OF LATEST CANADIAN TEST RESULTS

A striking example of the very real industrial relevance of the newly concluded Canadian test work was also presented to members of the consultative-group. It involves one of the great Canadian tar-sand operations. Here, serious operating problems (involving frequent shut-downs) have arisen, due to a recent increase in the solids particle sizes, from the previously encountered fine (some 0.17 mm) to an intermediate (some 0.33 mm) grain size.

It should be noted that this is the very transition PSD range covered by the present Canadian test-work, being reported herein. It is, therefore, thanks to these very results that a reliable insight can be gained into the problematic fluid-dynamic situation in question. This, in turn, makes suggestions for remedial steps possible on a scientific, rather than on a purely empirical, basis.

The foregoing situation also fully vindicates the decisions taken previously, as documented in CANMET Report 84-70(1), namely:

(a) that, apart from coal-slurries, the proposed joint Canadian/FRG research project also include experiments with non-degrading sands within narrowly defined PSD ranges; and

(b) that general attention be directed towards applying, and if possible, expanding and improving the mechanistic two-layer slurry pipeline model.

Moreover, the aforementioned situation also highlights the practical importance of continuing with the present program, so that it include all the originally suggested work, and, in particular, tests with larger particle sizes and with additional (both larger and smaller) pipe sizes.

It should be noted that the above mentioned industrial difficulties involve much larger pipe-sizes than the one used for the present Canadian tests. It is, therefore, noteworthy that only a mechanistic model allows reliable conclusions to be transferred, with confidence, between differing pipe sizes.

GENERAL INDUSTRIAL RELEVANCE OF SLURRY-PIPELINING RESEARCH

In addition to discussing the immediate industrial relevance of the newly acquired Canadian test results, the consultative group also noted the general context within which slurry-pipelining research needs to be considered, both in Canada and Germany.

(1) In Canada

Several examples, of both present and future relevance were discussed. These included:

(a) The situation at the Cape Breton Development Corporation's (DEVCO) underground mines in Sydney, N.S. Here coal has to be hauled some 4 to 5 miles, on an incline, from under the sea to surface. In this case safety rather than purely economic reasons call for serious consideration of pipelining, because the use of conveyor belts in an explosive atmosphere is known to involve risks.

(b) The situation arising at the Canadian tar-sands operations. Here, enormous volumes (several 100,000 t per day) have to be hauled by the existing pipelines. The design and control of these existing pipelines has, so far, been concerned with fine (some 0.17 mm) particle sizes. Now, at one mine, serious problems have arisen due to the presence of intermediate (some 0.33 mm) particle sizes. The existing lines are mostly 450 to 550 mm diameter in size, and up to 10 km in length. The control problems in question are, accordingly, considerable. A reliable solution to this type of problem requires the existence of a fully developed, rational model. It alone can deal with all relevant parameters whose individual effects cannot possibly be studied, within practical time and cost-given constraints, by experimental means.

(c) At tar-sand operations pipelining, instead of expensive trucking, of oversize rejects is also of considerable interest. These materials are very hard to handle especially during the winter (while the frozen ground is easier to truck over), while in the summer the situation is reversed. Yet, no pipelines have, so far, been installed for this purpose. This is because a 'first' in this situation involves unacceptable risks without the assurance of a foolproof operation, based on a reliable and well understood model. The material quantities involved just do not allow for the risk of a shut-down, which would overwhelm the entire operation in no time: therefore, the development of a good theoretical model is called for.

(d) Westar, in British Columbia, has R.O.M. coal pipelines from its hydraulic mine to its coal washery plant. Although these lines are not operational at the moment due to general coal-economic reasons, they will, no doubt, reopen in the future. The development of answers to possible future fundamental problems, should, therefore, be undertaken now. Westar are also operating tailings pipelines.

(e) The hydraulic-hoisting pipeline at Falconbridge's Onaping No. 1 mine (near Sudbury, Ontario) has also been shut-down until recently, for general economic reasons. Now, however, it is expected to be back in operation by early 1986. It is designed to handle some 379 t/h of minus 3 in. copper-nickel ore through a 9-3/4 in. diam rock bore, from the 2350 level to surface. Total installed capacity is in the order of 2000 HP. Many of the initial operating problems (that may always be expected at the start-up of new installations) could probably again be diagnosed on the basis of a good, fundamental, pipelining model.

(f) Another existing pipeline operates at the Key Lake uranium mine (of Uranerz/PCS) in Northern Saskatchewan. This is a 1000 m long slurry-pipeline connecting the gyratory-crusher building to the mill. It is used to transport crushed ore at some 6.5 ft/sec, and at a weight concentration of 40 to 50%. The line runs alongside a steam pipe inside a utilidor. In case of unexpected operational problems the existence of a good model will again pay for itself many times over.

(g) Apart from the very real industrial relevance of slurry-pipelining research in case of operating mines (as indicated above), appropriate knowledge is of great importance in case of future mine developments as well. As an example:

(i) In case of a conventional development situation, the practical advantages of a pipelining system vs. skip hoisting could include the following:

- Lower first costs; either by allowing the use of an existing shaft (otherwise too tight for operational requirements), or by saving possibly up to one year in the development time of a new property (since hoisting can be established at the very outset, thus allowing for on-going removal of wastes as the mine is being developed).

- The possibility of a one-man hoisting operation, and that from a remote location, possibly on surface.
- Lower peak-power requirements, than with skip hoisting.

(ii) In case of non-conventional, specialized mine developments. Here slurry-pipelining might offer the most likely, if not the only possible solution. One such situation exists in case of the high grade uranium deposit, at Cigar Lake in Saskatchewan. In this case CANMET's contractor (Contract RN 23440-4-9139, DSS No. OSQ 84-00367, on "Development of an Underground Mining Method for Exploitation of Very High Grade Uranium Deposit at Medium Depth of 200 to 350 m") concluded that the most likely way to handle the very high grade uranium ore under practically feasible conditions entails the hydraulic transportation of drill cuttings, plus slurry transportation from underground to surface. In addition, a study by the mining company itself ("The Cigar Lake Project - Concepts for Mining High Grade Unconformity Uranium Ores, Athabasca Basin, August 1985, 47 pp") also concludes that the most promising mining method involves transportation of the cuttings by drilling mud to the surface (some 450 m vertically).

(2) In Germany

Professor F.J. Geller explained that, partly due to the somewhat different short-term problems at the FRG and Canadian mines, and partly due to the difficult economic situation in general, pipelining was of little immediate practical domestic interest. It was, however, of great fundamental interest, especially in view of the many important commercial links the FRG had with China and with Eastern Bloc countries. Here the potential of interesting export orders, involving hydraulic pipelines as well, is of immediate and very real interest. Consequently, German scientists are just as anxious to keep fully abreast of modelling developments, as are their Canadian counterparts, even though the German coal industry as such is not, at the present, interested even in co-financing new hydraulic pipeline tests. In this context it is also unfortunate that a very important export order for an iron ore pipeline to the USSR, which a German consortium of firms had expected to receive, eventually went to Italian firms, led by SNAMPROGETTI of Fano.

Any proposed extension of the present Canadian work to Germany should, therefore, take this situation into account, by omitting new pipelining tests and by concentrating on fundamental research aspects. Particular note should also be taken of Canadian advances in the development of the mechanistic two-layer model, and of the reference made to the complications arising from the presence of clays in the solids (German coals contain clays!).

DISCUSSION OF RECOMMENDED FUTURE GERMAN WORK

After taking note of the aforementioned very encouraging results achieved to date by the Canadian test work, and also of the industrial benefits that have already accrued from even the incomplete results obtained so far, the consultative meeting discussed the best way a future German project could dovetail with the results already achieved. It was recognized that such work would have to be conducted within the practical limitations outlined earlier by Professor F.J. Geller, namely:

(a) that no actual pipeline tests could be conducted in Germany within the foreseeable future;
(b) that overall financial resources were strictly limited; and
(c) that, at the technical level, the physical resources were more or less limited to those represented by a project-leader, his full-time assistant, and by several undergraduate/graduate students.

It was also noted that the proposed work should be helpful to both Germany and Canada.

In addition it was agreed that the work in Germany should preferably be undertaken by a well-established, non-profit, research/academic type organization with close ties to the mining industry; possibly by one which is well-known (both at home and abroad) through its previous international contacts in the field of hydrotransport. It was noted that such an organization could receive all appropriate help and information from its Canadian counterparts on behalf of the German slurry-transport group as a whole, and not merely for its own internal benefit.

It was agreed that the WBK organization of Bochum, with Professor F.J. Geller as project leader and Dipl. Ing. C. Hartbrich as his full-time assistant (assigned to this program alone) would fully satisfy all the foregoing requirements.

As to their specific tasks it was agreed that, should they indeed be unable to undertake new pipelining tests, they should then assemble a very complete documentation of all those previously conducted German hydrotransport experiments which, as is known, contain a large number of the very tests with large particle sizes (up to some 63 mm) and in several pipe-sizes, that:

(a) are of great interest to the Canadian research group as well;
(b) cannot, and in any case should not, be re-run in Canada at this time; and
(c) would complement the test-series most recently conducted in Canada by the SRC on behalf of CANMET.

Apart from assembling and fully documenting the existing German experimental results, the German group's work should also include tests to supplement these data with additional measurements. These are to include such important data as the carrier fluid's viscosity and the contact load's sliding coefficient of friction, i.e., data that are relatively easily obtainable even with limited funds, equipment, and personnel. The Canadian group is prepared to share the use of their own equipment with the German experimenters for this purpose, or otherwise assist them as far as possible.

In addition, the German group is to use the test data thus obtained to further develop, modify (e.g., by paying special attention to clay contents) or simply to verify the latest version of the Wilson/Shook two-layer mechanistic model, as it was presented to, and discussed with the consultative-group in Saskatoon on November 18 and 19, 1985. Here again Professor C.A. Shook (on behalf of the Canadian group) is willing to assist Professor Geller and his group in their task, either in Saskatoon (if they wish to visit with him there), or by himself briefly visiting Germany (in either case all out-of-pocket expenses are to be paid by Germany).

At some undetermined future date, and after the foregoing tasks have been successfully completed, the German group might also consider:

(a) measuring additional slurry-parameters of interest to the mechanistic two-layer model in question, that can be obtained without the use of a sophisticated pipeline laboratory;
(b) assemble, fully document, and evaluate (as to their relevance to the Wilson/Shook model) other than the German test data, e.g., the ones obtained by the U.S. Bureau of Mines;
(c) assemble, and fully document, other pertinent coarse slurry test data of practical interest, such as pump efficiencies at conditions of industrial interest, wear and degradation data, and the like.

DISCUSSION OF RECOMMENDED FUTURE CANADIAN WORK

It was agreed that the newly acquired Canadian test results indicate the correctness of the approach recommended by the CANMET report, outlining the proposed Canada/FRG project (1). Specifically, the correctness of the approach used by the mechanistic model was vindicated, as well as the immediate practical relevance of the results to industrial problems. Moreover, the importance of testing narrow size-fractions of a non-degrading material was also demonstrated. Consequently, it was agreed that future Canadian work should cover as many more of the original work statement's uncompleted phases (See Appendix 'B' of Ref. 1) as available funds will permit.

In this context the December 1984 costs for testing the appropriate gravel-slurries should be noted:

(a) in a 100 mm pipeline these were estimated to be about $78,700 overall; and
(b) in a 500 mm pipeline, about $57,600 overall.

M. Mikhail thought that no more than some $60,000 to $70,000 would be available for the next phase of the Canadian test work. Dr. Husband suggested that, if a go-ahead were to be given in the near-future, much of the original schedule could, probably, still be completed this fiscal year (i.e., by March 31, 1986).

TIMING OF NEXT CSWG MEETING

Professor F.J. Geller suggested that he would endeavour to submit a full report about the Saskatoon consultative-group meeting to the German group as soon as possible. He was of the opinion that by doing so, he and his colleagues could study the recommended German work-load in depth before the next Coal-Slurry-Working-Group (CSWG) meeting in Germany. Thereby they could, hopefully, be ready with their final reply, or at any rate discuss its tentative details with the Canadian group, at this meeting. It was, therefore, important to have some indication of its likely date, and composition.

In reply it was explained that the date of the next CSWG meeting depended, almost entirely, on how the dense-coal combustion tests would be progressing. So far a number of difficulties remain unsolved. Even tentatively, therefore, an early March 1986 date seemed the soonest likely one.

As for the Canadian contingent at the next CSWG meeting, it was explained that Professor C.A. Shook had been asked to join the group. Professor Shook had kindly agreed to consider the matter favourably, provided ample leadtime (say 4 to 6 weeks) was given, and provided the date was no later than March 1986, or thereabouts. In addition financing Professor Shook's out-of-pocket expenses also still had to be discussed with Dr. Brown in Edmonton; the funds allotted for the initial two phases of the Canadian test work, including the small carryover to Fiscal Year 1985/86, had actually all been committed by now. They could, therefore, not be used for the trip in question.

SUMMARY

On reviewing progress to date, as well as expectations for the future, the consultative-group noted the following:

(a) The Canadian group has successfully completed its test series in a 250 mm pipeline; these tests included the 'Core Project' with narrow-fraction gravel slurries, as well as experiments with a broad fraction Western Canadian coarse-coal-slurry.

(b) The results of the Canadian test series are very encouraging; although only about 50% of the originally scheduled Canadian program has been completed so far, and none of the German tests, a new (even if only tentative as yet) modelling-correlation has

been obtained for the prediction of the slurry's contact-load ratio. This correlation was shown to be most reliable in the region covered by the present series of Canadian experiments.

(c) The mechanistic model was shown to be applicable to a range of substantially different solids (as to their respective densities) and, therefore, to R.O.M. coals as well.

(d) The mechanistic model now covers the transition region between fine and coarse particles. In fact, at its present stage of development, it is most reliable in the fine particle, and in the transition region. The remaining, i.e., very coarse, region represents the area where future development is required.

(e) The results of the Canadian test series were shown to have immediate practical relevance in the area of tar-sands pipelining: here serious operating problems have arisen due to an increase in the solids particle sizes from fine to intermediate. This is, however, the very transition PSD range covered by the present experiments. Suggestions for remedial action can, therefore, now be made on a scientific, rather than purely empirical basis. This is so because the mechanistic model alone allows reliable conclusions to be transferred, with confidence, from one pipe-size to another, and even in case of different types of solids.

(f) Apart from the specific industrial relevance, referred to above, the importance of slurry-pipelining research to other Canadian mining situations, both present and future, was also established.

(g) It was agreed that the usefulness of the present Canadian results would be greatly enhanced if additional tests were run with larger particle sizes, and with both larger and smaller pipe sizes. Completion of the originally scheduled Canadian program was, therefore, recommended.

(h) It was noted that due to financial restraints, none of the originally scheduled German work could be undertaken so far.

(i) It was also noted that while none of the originally scheduled laboratory pipelining experiments can be undertaken by the German hydrotransport group within the foreseeable future, they are very anxious to keep abreast of developments in slurry pipelining research.

(j) It was agreed that both German and Canadian research would benefit, if the German group could:
   (1) assemble and fully document the results of previously conducted German hydrotransport experiments;
   (2) supplement these data by running additional tests, of value to the further development of the mechanistic two-layer model; the results of these tests should be relatively easily obtainable, even with limited funds, personnel and equipment;
   (3) use the aforementioned data to further develop, modify, or simply verify the Wilson/Shook mechanistic model;
   (4) assemble, and fully document, other than the German test data as well (e.g., the ones from the U.S. Bureau of Mines) for the same purpose as mentioned in points (1) to (3) above.

(k) The Canadian group agreed to assist the work of their German colleagues, with both equipment and advice.

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5. Hartbrich, C. "Anwendung des Zwei-Schichten-Modells von Wilson/Shook auf den hydraulischen Transport grobkörniger Feststoffe" (Application of the two-layer model of Wilson/Shook to the transportation of coarse solids); WBK, Thesis Report No. FHB84HTR; 44 pp (May 1985) - in German.

APPENDIX 'A'

CANADA/FRG MOU ON COAL SLURRY SYSTEMS

Government of Canada / Gouvernement du Canada

MEMORANDUM **NOTE DE SERVICE**

A-1

SECURITY - CLASSIFICATION - DE SÉCURITÉ	
OUR FILE — N / RÉFÉRENCE	
YOUR FILE — V / RÉFÉRENCE	
DATE	September 6, 1984

TO / A: All interested parties
Cda/FRG Slurry MOU
(See Attachment 1)

FROM / DE: W.G. Jeffery
Director-General
CANMET

SUBJECT / OBJET: Canada/FRG Memorandum of Understanding (MOU) on Coal Slurry Systems

I am pleased that the MOU has been signed by Dr. Finke for Bundesministerium Für Forschung Und Technologie (BMFT) and myself on behalf of EMR/Canada. For the files and awareness of everyone, I herewith attach a copy of the signed MOU.

The subject area of research has a broad spectrum of interest both within EMR and across Departments. Now that CANMET has assumed responsibility for this particular research agreement, I wish to outline the mode of operation, the responsibilities and the range of interaction within the Canadian government. These points are outlined in the attached notes.

While CANMET is ultimately accountable for the successful delivery of this international agreement, I count on the cooperation and goodwill of all interested parties and look forward to a useful and beneficial program of work.

W.G. Jeffery

WGJ:naf

Attachments

CANADA/FRG MOU Coal Slurry Systems

Description of Canadian Operations

1. Responsibility for carrying out the obligations of the MOU and acting as Canadian Coordinator has been delegated to Dr. David Brown, Director, Coal Research Laboratories, CANMET, based in Edmonton. (Note that this is a change in paragraph 1 of the agreement in the transfer of these responsibilities from Dr. Ogle, OERD/EMR.) His alternate contact in Edmonton is M. Mikhail, CRL.

2. As a reference point within Ottawa, Mr. A.S. Romaniuk is a member of the Coal Research Laboratories who reports directly to Dr. Brown. He will assist in the administration and coordination of the work.

3. Dr. Brown will be the Canadian Coordinator of the Coal Slurry Working Group (CSWG).

4. The MOU embodies four components. The assigned Canadian contacts are from different units of EMR and Transport Canada. Until otherwise changed by their organizations, these are:

   (a) Dense Coal Slurry Systems: W. Warfe, Coal and Alternative Energy Branch, EMR.

   (b) Hydraulic Transportation of Coking Coal: M.W. Mikhail, Coal Research Laboratories, CANMET, EMR.

   (c) Coarse Coal Slurry Short Distance Pipelining: L. Geller, Mining Research Laboratories, CANMET, EMR.

   (d) Manual on Design of Slurry Pipelines: I. Gilbert, Research and Development, Transport Canada.

   These contact persons, together with Mr. G. McLaughlin of the Canadian Transport Commission and Dr. Brown and any of his staff that he nominates, effectively form the Canadian Working Group.

5. All Working Group members are expected to keep other interested members of their organizations informed of the activities within the MOU, in addition to any wide circulation of material by Dr. Brown or External Affairs to the list of interested parties (Attachment 1).

6. Overall reporting responsibility by Dr. Brown for progress in the MOU is to W.G. Jeffery, Director-General, CANMET, by quarterly report through the fiscal year, together with appropriate reports to the Consultative Canada/FRG Meetings.

W.G. Jeffery

CANMET
September 1984

Memorandum of Understanding between the B.M.F.T. and E.M.&R. on Coal Slurry Systems

During a meeting held on January 26, 1984, in Ottawa, which was attended by the participants listed in the Annex, representatives of both sides reviewed Annex 13 of the 7th Consultative Canada/-Federal Republic of Germany meeting of May 4-5 1983 with a view to arriving at a joint Plan of Action in the field of Coal Slurry Systems. The following understanding was reached:

1. The two sides agreed to create a Working Group referred to as the Coal Slurry Working Group (CSWG), headed by two Coordinators identified as Dr. Ogle from the O.E.R.D./E.M.&R. and Mr. Fiseni from TÜV Rheinland, Consultant for the B.M.F.T.

2. The mandate of the C.S.W.G. is to ensure that progress is made by both parties in the cooperation on Coal Slurry in general by identifying specific fields of interest for scientists of the two parties to work on. The C.S.W.G. members will meet when they deem it is necessary and will report no later than prior to the next Consultative Meeting.

3. Regarding item 1 of Annex 13 referred to above, dealing with Dense Coal Slurry Systems, the parties agreed that the C.S.W.G. should explore four areas of potential cooperation in preparation, transportation and combustion of coal slurry, as well as looking at the marketing and commercial aspects of a coal slurry system. The C.S.W.G. would report on the results of

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their exploration by November 1984. The two Contact Persons of this project are Professor Wiedenroth for the German side and Mr. Warfe from E.M.&R. for the Canadian side. Their main mandate is to develop specific topics for cooperation with a view to avoiding duplication of R&D and in order to develop complementary fields of expertise. The two Contact Persons will make their best effort to identify the necessary funding (the German side has already identified funds from the B.M.F.T. The Canadian side will identify funds provided consultation with provinces and industry confirms their interest in the area).

4. Regarding item 2 of Annex 13, dealing with Hydraulic Transportation of Coking Coal, the two parties agreed that R&D Work was sufficiently advanced for their needs and that results of the studies performed should be exchanged between the parties concerned, which will get in direct contact to make the necessary arrangements. The item would be reviewed at the next Consultative Meeting.

5. Regarding item 3, dealing with coarse coal slurry short distance pipelining, it was agreed that the two contact persons identified as Mr. Geller from the Federal Republic of Germany and Mr. Geller from E.M.&R. for Canada would pursue cooperative work in that field, identifying very specific areas of cooperation and would report to the Coordinators of the C.S.W.G. at the latest prior to the next meeting of the Canada/Federal Republic of Germany Consultative Meeting.

6. Regarding item 4, dealing with Manual on Design of Slurry Pipelines, it was agreed that the C.S.W.G. would work towards harmonization of international standards for compatibility of slurry systems design and regulatory aspects (including manuals). It would start by exchange of information such as terms

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of reference from both sides (Canada, CTC, has already transmitted its draft terms of reference). Both sides agreed that when work is completed in each country, they would exchange their work for comments and potential integration of common standards (Canadian side wishes to receive a critical analysis on their paper from the German side which the latter agreed to transmit before the end of April 1984).

This Memorandum of Understanding shall enter into force at the date of the last signature and shall also apply to Land Berlin, provided that the Government of the Federal Republic of Germany does not make a contrary declaration to the Government of Canada within three months of the date of entry into force of this Memorandum of Understanding.

Done in Ottawa on July 18, 1984 and in Bonn on 6th June, 1984

for E.M.&R. for B.M.F.T.